Asymmetry Analysis Using Automatic Segmentation and Classification for Breast Cancer Detection in Thermograms

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Abstract— **Thermal infrared imaging has shown effective results as a diagnostic tool in breast cancer detection. It can be used as a complementary to traditional mammography. Asymmetry analysis are usually used to help detect abnormalities. However, in infrared imaging, this cannot be done without human interference. This paper proposes an automatic approach to asymmetry analysis in thermograms. It includes automatic segmentation and pattern classification. Hough transform is used to extract the four feature curves that can uniquely segment the left and right breasts. The feature curves include the left and the right body boundary curves, and the two parabolic curves indicating the lower boundaries of the breasts. Upon segmentation, unsupervised learning technique is applied to classify each segmented pixel into certain number of clusters. Asymmetric abnormalities can then be identified based on pixel distribution within the same cluster. Both segmentation and classification results are shown on images captured from Elliott Mastology Center.**

Keywords— **asymmetry analysis, breast cancer detection, thermogram, Hough transform, pattern classification, unsupervised learning**

I. Introduction

Making comparisons between contralateral images are routinely done by radiologists. When the images are relatively symmetrical, small asymmetries may indicate a suspicious region. This is the underlying philosophy in the use of asymmetry analysis for mass detection in breast cancer study [2]. Unfortunately, due to various reason like short of radiologists, fatigue, carelessness, or simply because of the limitation of human visual system, these small asymmetries might not be easy to detect. Therefore, it is important to design an automatic approach to eliminate human factors.

There have been a few papers addressing techniques for asymmetry analysis of mammograms [2], [7], [8], [9], [10], [11]. [3], [5] recently analyzed the asymmetric abnormalities in infrared images. In their approach, the thermograms are segmented first by operator. Then breast quadrants are derived automatically based on unique point of reference, i.e. the chin, the lowest, rightmost and leftmost points of the breast. In an earlier paper we published [6], Hough transform is used to segment the image, and curvature analysis is proposed to identify the abnormalities. This paper extends our work on using Hough transform for segmentation. New experimental results are provided. Instead of using curvature analysis which is very sensitive to noise, this paper describes a pattern classification approach which uses unsupervised learning to identify abnormalities. k-means algorithm is applied on the segmented images.

Testing images are obtained using the Inframetrics 600M camera, with a thermal sensitivity of 0.05^0K.

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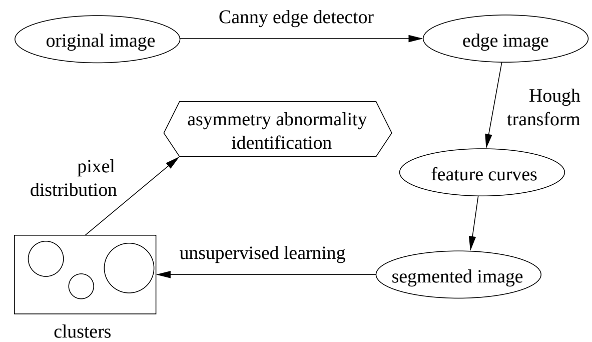

Fig. 1. Procedure of automatic asymmetry analysis of thermogram.

II. Approach

Figure 1 is a block diagram of the five procedures involved in the proposed approach: (1) *Edge image* detection by Canny edge detector; (2) *Feature curve* extraction including the left and right body boundary curves, and the two lower boundaries of the breasts. Hough transform is used to detect the parabolic shaped lower breast boundaries; (3) *Segmentation* based on the intersection of the two parabolic curves and the line formed by the two armpits; (4) *Pattern classification* using unsupervised learning to group each pixel of the segments into certain clusters; and (5) *Pixel distribution* of each cluster is analyzed and abnormalities can then be identified.

A. Edge detection by Canny edge detector

Edge image is first derived by using Canny edge detector [1]. The standard deviation is chosen to be equal to 2.5 so that only strong edges are detected.

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B. Feature curve extraction by Hough transform

There are four dominant curves appeared in the edge image which we called the feature curves: the left and right body boundaries, and two lower boundaries of the breasts. The body boundaries are easy to detect. Difficulties lie in the detection of the lower boundaries of the breasts. We observe that the breast boundaries are generally in parabolic shape. Therefore, Hough transform [4] is used to detect the parabola.

C. Segmentation

Segmentation is based on three key points: the two armpits (P_L, P_R) derived from the left and right body boundaries by picking up the point where the largest curvature occurs, and the intersection (O) of the two parabolic curves derived from the lower boundaries of the breasts. The vertical line that goes through point O and is perpendicular to line $P_L P_R$ is the one used to separate the left and right breasts.

D. Unsupervised learning

Pixel values in a thermogram represent the thermal radiation resulting from the heat emanates from the human body. Different tissues, organs and vessels have different amount of radiation. Therefore, by observing the heat pattern, or in another word, the pattern of the pixel value, we should be able to discover the abnormalities if there are any.

Usually, in pattern classification algorithms, a set of training data are given to derive the decision rule. All the samples in the training set have been correctly classified. The decision rule is then applied to the testing data set where samples have not been classified yet. This classification technique is also called supervised learning. In unsupervised learning, however, data sets are not divided into training sets or testing sets. No *a-priori* knowledge is known about which class each sample belongs to.

In asymmetry analysis, none of the pixels in the segment knows its class in advance, thus there will be no training set or testing set. Therefore, this is an unsupervised learning problem. We use k-means algorithm to do the initial clustering. k-means algorithm is described as follows:

1. Begin with an arbitrary set of cluster centers and assign samples to nearest clusters;
2. Compute the sample mean of each cluster;
3. Reassign each sample to the cluster with the nearest mean;
4. If the classification of all samples has not changed, then stop, else go to step 2.

E. Within cluster pixel distribution

After each sample is relabeled to a certain cluster, the cluster mean can then be calculated. The segmented image can also be displayed in labeled format. From the difference of mean distribution, we can tell if there is any asymmetric abnormalities.

III. Experimental Results

Testing images are obtained using the Inframetrics 600M camera, with a thermal sensitivity of 0.05^0K. The image are collected at Elliott Mastology Center. Results from two testing images (lr, nb) are shown here.

Figure 2 shows the intermediate results from edge detection, feature curve extraction, to segmentation. From the figure, we can see that Hough transform can derive the parabola at the accurate location.

Figure 3 provides the histogram of pixel value from each segment with 10-bin setup. We can tell just from the shape of the histogram that lr shows a more apparent abnormalities than nb. However, histogram only reveals global information.

Figure 4 displays the classification results for each segment in its labeled format. Here, we choose to use four clusters. The figure also shows the mean difference of each cluster in each segmented image. From Fig. 4, we can clearly see the much bigger difference shown in the mean distribution or image lr which can also be observed from the labeled image.

IV. Conclusion

This paper describes an automatic approach for asymmetry analysis in thermograms to help identify abnormalities. It includes an automatic segmentation using Hough transform and an unsupervised pattern classification for segment comparison. From the experimental results, we can see that Hough transform can accurately extract the feature curves, and k-means algorithm provides useful information in the analysis of abnormalities.

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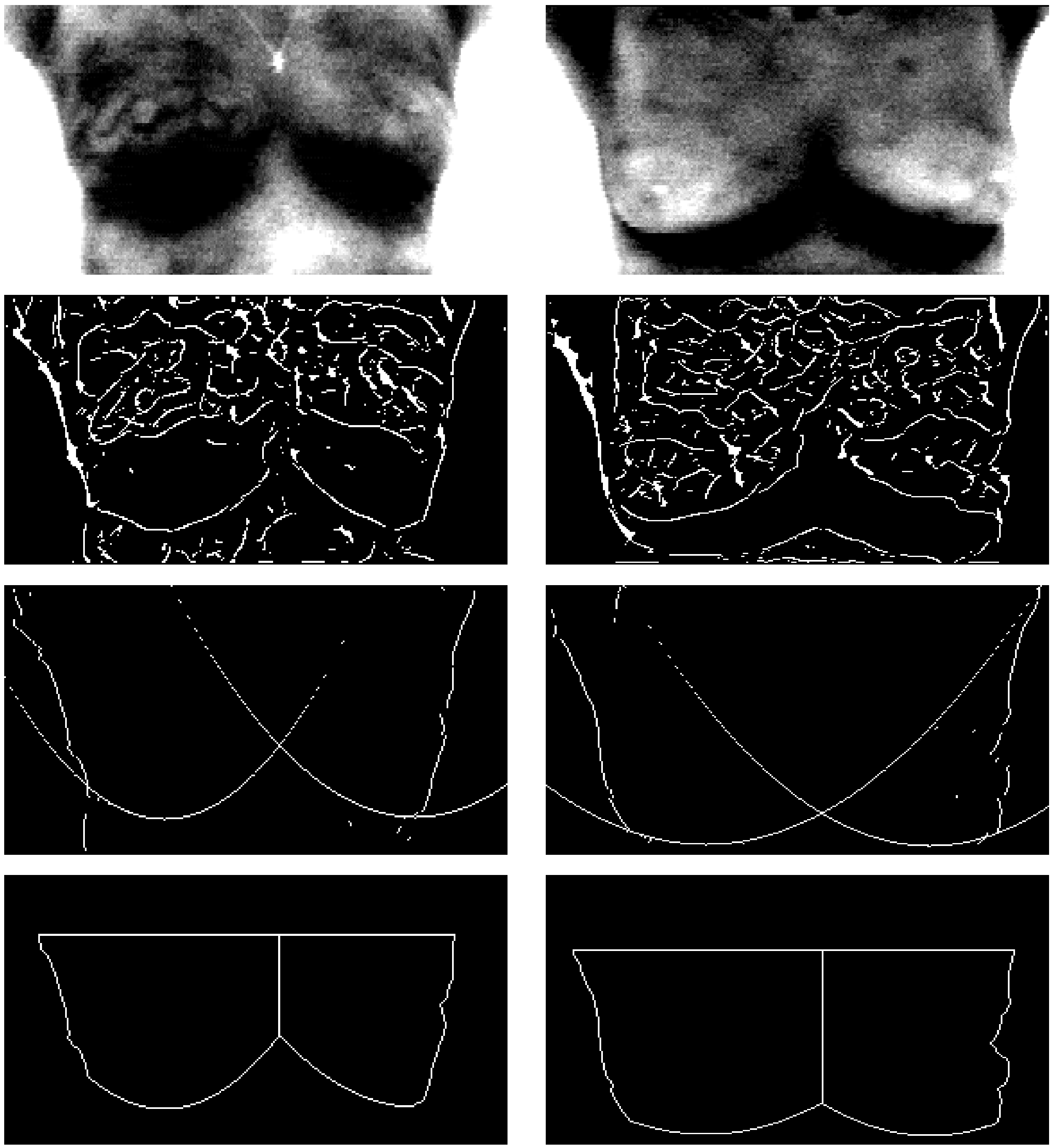

Fig. 2. Segmentation results of two images. Left: results from lr. Right: results from nb. From top to bottom: original image, edge image, four feature curves, segments.

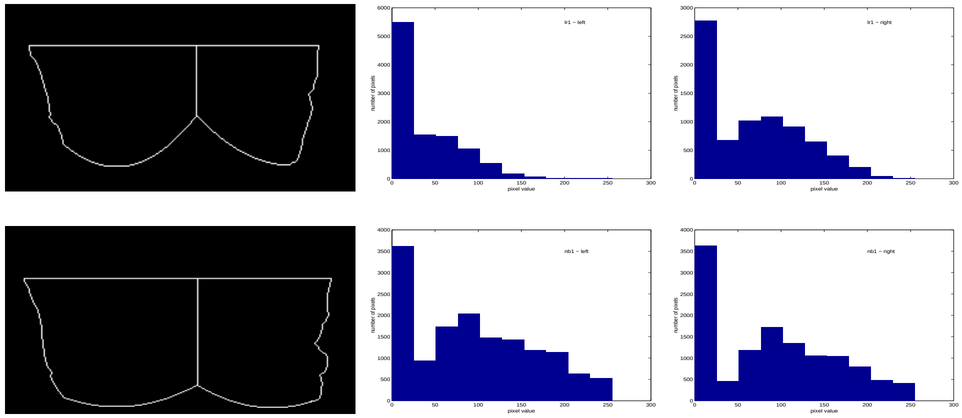

Fig. 3. Histogram of the left and right segments. Top: results from lr. Bottom: results from nb. From left to right: the segments, histogram of the left segment, histogram of the right segment.

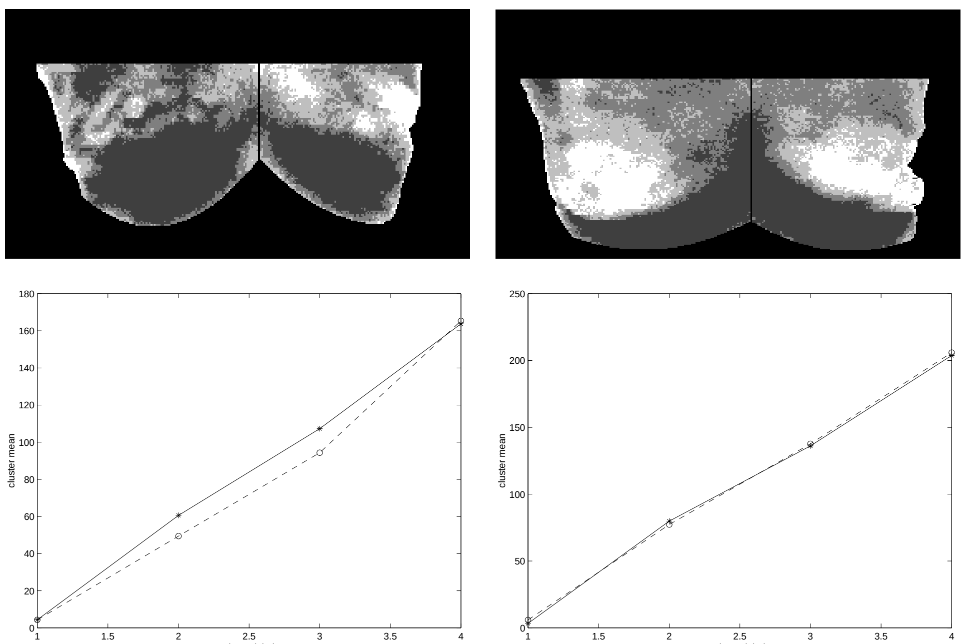

Fig. 4. Labeled image and the profile of mean for each cluster. Left: results from lr. Right: results from nb. Top: labeled image. Bottom: average pixel value profile of each cluster

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